Agronomical interventions for enhancing seed size tubers in potato (*Solanum tuberosum*) variety kufri khyati

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ABSTRACT

The present experiment was conducted during 2020–21, 2021–22 and 2022–23 at Regional Station, ICAR-Central Potato Research Institute, Gwalior, Madhya Pradesh to evaluate the best spacing combination and dehaulming time for enhancing the seed size potato (*Solanum tuberosum* L.) tubers and profitability under north-central plains of India. Experiment was conducted in a split-plot design (SPD) comprised of 3 spacing combinations, viz. S1, Ridge and furrow 60 cm × 20 cm (Control); S2, Ridge and furrow 60 cm × 15 cm; S3, Flatbed paired row 90 cm bed width (two rows at 40 cm × 20 cm plant to plant spacing); S4, Flatbed paired row 90 cm bed width (two rows at 40 cm × 15 cm plant to plant spacing); and S5, Flatbed triple row 90 cm bed width (three rows at 20 cm × 20 cm plant to plant spacing) in main plot and 2 haulm killing dates, viz. 70 and 80 days after planting in sub plots. The treatment S2, Flatbed triple row 90 cm bed width (three rows at 20 cm × 20 cm plant to plant spacing) spacing combination significantly increased the number and weight of seed size tubers, net seed size and total tuber yield when dehaulmed was done after 80 days. The highest increase in seed size and total tubers over control reported when dehaulmed at 70 days. However, the treatment S5, Flatbed paired row 90 cm bed width (two rows at 40 cm × 20 cm plant to plant spacing) with 80 days haulm killing recorded highest seed size tuber 58.03% and benefit cost (B:C) ratio of 2.51:1 among all other treatment combinations. Though, treatment S3 i.e. flatbed paired row 90 cm bed width (two rows at 40 cm × 20 cm plant to plant spacing) with 80 days haulm killing combination require higher seed rate but can be an economically viable option for enhancing seed size tuber percent and B:C ratio.

Keywords: Agro-techniques, Haulming, Seed size, Spacing, Variety

High yielding early bulking varieties of potato (*Solanum tuberosum* L.), viz. Kufri Khyati, Kufri Pukhraj, Kufri Mohan and Kufri Lima are very popular for cultivation in India. Among them Kufri Khyati performs well both under very early @60 days and early @75 days (Kumar et al. 2009) and when grown under seed production for 70–80 days produces higher percentage of non seed size tubers and less percentage of seed size (25–125 g) tubers (Sadawarti et al. 2017) which is less than 50% or around 50% with different agro-techniques (Sadawarti et al. 2022). This higher per cent of non-seed size tubers is a major concern/challenge for seed potato producing organizations (formal system) like ICAR-Central Potato Research Institute, State Agricultural Universities (SAU), State Departments (Horticulture/ Agriculture), National Seed Corporation (NSC) and State Farm Corporation of India (SFCI), State Seed Corporation (SSC) and Cooperative societies etc. which are involved in Foundation Seed-I, Foundation Seed -II and certified seed production and also to progressive seed potato growers (informal system).

The size of the seed tuber has a significant impact on overall yield, hence it is important to consider it while determining the seed rate (Dagne et al. 2018). Seed makes up 40–50% of the total production cost. Hence, increasing seed size tuber per cent in early bulking variety like Kufri Khyati is of utmost important researchable issue for seed potato production (Singh and Pandey 2013). At field level different agro-techniques like adjustment in planting geometry, canopy management and nitrogen levels have been tried to maximize the seed tuber size by different workers in different varieties (Farahvash and Iranbakhsh 2009, Singh and Singh 2016, Singh et al. 2019, Sadawarti et al. 2023, Kumar et al. 2023, Kumar et al. 2023).
Quantitative differences between the conventional ridge and furrow system and bed planting are scanty (Kumar et al. 2023). Economic viability (B:C ratio) needs to be taken into consideration while developing/standardizing different agro-techniques for seed potato production (Kumar et al. 2023). With this background present investigation was undertaken with different spacing combinations and haulm killing duration to enhance seed size tubers in high bulking potato variety Kufri Khyati.

**MATERIALS AND METHODS**

The present experiment was conducted during 2020–21, 2021–22 and 2022–23 at Regional Station, ICAR-Central Potato Research Institute, Gwalior, Madhya Pradesh. Treatments consisted of 5 spacing combinations as main plot, viz. S1, Ridge and furrow 60 cm × 20 cm (Control) with plot size 10.8 m²; S2, Ridge and furrow 60 cm × 15 cm with plot size 10.8 m²; S3, Flatbed paired row 90 cm bed width (two rows at 40 cm × 20 cm plant to plant spacing) with plot size 8.1 m²; S4, Flatbed paired row 90 cm bed width (two rows at 40 cm × 15 cm plant to plant spacing) with plot size 8.1 m²; and S5, Flatbed triple row 90 cm bed width (three rows at 20 cm × 20 cm plant to plant spacing) with plot size 8.1 m² and 2 haulm killing dates as sub plots, viz. 70 and 80 days after planting in a split-plot design. Planting was done during the final week of October in 2020–21, 2021–22 and 1st week of November in 2022–23 with well-sprouted 40–50 g tubers. Nitrogen, phosphorus, and potassium, were applied at rates of 150, 80 and 100 kg/ha, respectively. According to standard seed plot techniques, the seed crop was grown. Observations on final emergence at 30 DAP and morphological attributes were recorded at 50 DAP and yield attributes at harvest of the crop respectively. Per cent seed size tuber and net tuber yield obtained by number and weight were calculated as:

\[
\text{Seed size tuber yield by number and weight} = \frac{\text{Total tuber yield by number and weight}}{\text{Total number of seed size tubers}} \times 100
\]

Net tuber yield obtained by number and weight = Total tuber yield obtained by number and weight - Seed tuber planted by number and weight.

**Statistical analysis:** Three year’s data were pooled and analyzed statistically and means were separated according to the least significant differences (LSD) at 0.05 level of probability.

**RESULTS AND DISCUSSION**

Emergence and growth characters: The different spacing combinations, haulm killing days and their interactions did not have significant effect on days to initial per cent 50% and final emergence (>93%), number of stems/plant, compound leaves/plant and plant height (Table 1). Present findings were supported by the results of Pavek et al. (2018), Singh et al. (2019), Sadawarti et al. (2022), Kumar et al. (2023). This might be due to the fact that uniform-sized, well sprouted and healthy seed tubers were planted (Singh et al. 2019). Besides, more or less favourable soil temperature and moisture conditions prevailed in all the plots (Alam et al. 2016, Sadawarti et al. 2023).

**Seed tuber yield:** Significant increasing trend was recorded in seed size tuber number and weight among spacing combinations and highest was recorded in S4 (526 thousand/ha by number and 30.70 t/ha by weight) over S1 control (323 thousand/ha by number and 18.11 t/ha by weight) (Table 2). Similar trend was reported for total and net tuber yield obtained both by number and weight (Fig. 1 and 2). Results are in agreement with studies conducted by Sadawarti et al. (2022), Kumar et al. (2023). Per cent seed size tubers did not affected significantly and ranged between 55–58% by number and 68–72% by weight (Fig. 3). Per cent seed size tubers were reported to 51% in conventional and 46% in flat bed system (Sadawarti et al. 2022). In earlier studies also it reported less or near 50% (Kumar et al. 2023). However, in the current study best treatment S4 which is economically viable having highest B:C ratio of 2.51:1 recorded highest 58.06% seed size tubers over other flatbed systems. Haulm killing at 80 days recorded significantly higher seed size tuber number (452000/ha) and weight (26.94 t/ha) over 70 days haulm killing (417000 by number) and weight (23.21 t/ha by weight). Similar trend was reported in total and net tuber yield obtained both by number and weight (Fig. 1 and 2). Results are in agreement with studies conducted by Sadawarti et al. (2022), Kumar et al. (2023). Per cent seed size tubers did not affected significantly and ranged between 55–58% by number and 68–72% by weight (Fig. 3). Per cent seed size tubers were reported to 51% in conventional and 46% in flat bed system (Sadawarti et al. 2022). In earlier studies also it reported less or near 50% (Kumar et al. 2023). However, in the current study best treatment S4 which is economically viable having highest B:C ratio of 2.51:1 recorded highest 58.06% seed size tubers over other flatbed systems. Haulm killing at 80 days recorded significantly higher seed size tuber number (452000/ha) and weight (26.94 t/ha) over 70 days haulm killing (417000 by number) and weight (23.21 t/ha by weight). Similar trend was reported in total and net tuber yield obtained both by number and weight (Fig. 3). 80 days haulm killing with flatbed recorded higher seed size and total tubers over conventional ridge and furrow (Sadawarti et al. 2022).

Increasing trend was recorded in magnitude of per cent increase in the seed size and total tuber number over control. Significant increase was reported in S4 seed size tubers (70.07%) and total tuber (76.03%) at 70 days of haulm killing over control. Similarly, by weight also, the magnitude of seed size tuber increased in S4 (71.96%) at 80 days haulm killing and total tuber (64.33%) at 70 days haulm killing (Fig. 3). The magnitude of per cent increase in the number of seed size tuber in paired row bed planting was 26.99 under Jalandhar condition of north-western India (Kumar et al. 2023) and 20.15% seed size and 24.13% total tuber under Gwalior condition of north-central India over the standard practice ridge and furrow (Sadawarti et al. 2022).
This increase in bed planting might be due to the tendency of roots to grow horizontally rather than vertically, which might have helped to extract more nutrients like nitrogen and water from soil, whereas, runoff from both the sides in ridge and furrow might led to ponding and infiltration which stimulate nitrogen leaching as revealed by Bradley et al. (2010).

Fisher et al. (1993) recorded the increase in water use efficiency in bed planting leading to maximize the yield associated traits. Like seed size and total tubers, significantly increasing trend was reported in case of small size (<25 g) tubers and highest was reported in closer spacing S5 (376 thousand/ha by number and 3.95 t/ha) over (Table 2).

Khalafalla (2001), Kumar et al. (2011), Mangani et al. (2015), Dawinder et al. (2020) also suggested that closer intra-row spacing resulted in development of greater number of smaller size tubers. Zabihi-Mahmoodabad et al. (2010) were of the opinion that increase in planting density creates competition for the nutrients within the plants that might lead to decline in tuber weight and size. Similar finding was reported by Singh et al. (2019) and Sadawarti et al. (2022). Non-significant but higher small size tuber number and weight was in 70 days Table 2

<table>
<thead>
<tr>
<th>Spacing combination/ Haulm killing days</th>
<th>Seed tuber number (thousand/ha)</th>
<th>Seed tuber yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;25 g</td>
<td>25–125 g</td>
</tr>
<tr>
<td></td>
<td>70 days</td>
<td>80 days</td>
</tr>
<tr>
<td>S1</td>
<td>202</td>
<td>184</td>
</tr>
<tr>
<td>S2</td>
<td>271</td>
<td>242</td>
</tr>
<tr>
<td>S3</td>
<td>272</td>
<td>299</td>
</tr>
<tr>
<td>S4</td>
<td>368</td>
<td>326</td>
</tr>
<tr>
<td>S5</td>
<td>385</td>
<td>367</td>
</tr>
<tr>
<td>Mean</td>
<td>300</td>
<td>284</td>
</tr>
<tr>
<td>CD (P=0.05) Spacing (A)</td>
<td>47.1</td>
<td>28.9</td>
</tr>
<tr>
<td>Haulm killing days (B)</td>
<td>NS</td>
<td>8.2</td>
</tr>
<tr>
<td>Factor (B) at same level of A</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Factor (A) at same level of B</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Treatment details are given under Materials and Methods. NS, Non-significant.
Table 3  Effect of different spacing combination and haulm killing days on economics of potato variety kufri khyati

<table>
<thead>
<tr>
<th>Spacing combination/ Haulm killing days</th>
<th>70 days haulm killing</th>
<th>80 days haulm killing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yield (t/ha)</td>
<td>Cost of production (₹/ha)</td>
</tr>
<tr>
<td>S₁</td>
<td>240.76</td>
<td>222114</td>
</tr>
<tr>
<td>S₂</td>
<td>275.20</td>
<td>253188</td>
</tr>
<tr>
<td>S₃</td>
<td>347.15</td>
<td>266458</td>
</tr>
<tr>
<td>S₄</td>
<td>365.32</td>
<td>306027</td>
</tr>
<tr>
<td>S₅</td>
<td>395.64</td>
<td>331003</td>
</tr>
</tbody>
</table>

Treatment details are given under Materials and Methods.

haulm killing over 80 days haulm killing in the present study (Table 2). In earlier studies dehauling at 70 days recorded higher small size tubers than delayed dehauling of 80 days (Sadawarti et al. 2022, Kumar et al. 2023).

In case of large size tubers (>125 g), only S₅. Flatbed paired row 90 cm bed width (two rows at 40 cm apart 15 cm plant to plant spacing) recorded significantly higher tuber number (55 thousand/ha) and weight (9.43 t/ha) over control (Table 2). The higher number of large size tubers in S₅ may be due to production of higher tubers than conventional spacing and wider spacing than S₅. 80 days haulm killing recorded significantly higher tuber number (51 thousand/ha) as well as weight (8.97 t/ha) over 70 days haulm killing. Significantly higher number of tubers was obtained in delayed haulm killing (Sadawarti et al. 2023).

Benefit : cost ratio: Any farming has direct relationship to benefits gained from it. Among spacing combinations and haulm killing days for seed potato production in the present study, highest gross return (₹843205/ha) and net return (₹490934/ha) was reported in S₅ at 80 days of haulm killing but highest B:C ratio was obtained in S₁ with 80 days haulm killing (2.51:1) (Table 3). Though higher seed yield, gross and net return was obtained in S₄ and S₅ treatment, the higher B:C ratio in S₃ is due to lower seed cost, lower labour requirement for harvesting and grading as compared to S₄ and S₅. Although, cost of cultivation remained maximum in paired row bed planting, due to higher seed cost. Higher cost of seed and management practices are main cause of major reason for high cost of potato cultivation (Azimuddin et al. 2009). 30th October planting with Kufri Khyati recorded highest gross return of ₹228,900/ha at 90 days harvest (Singh et al. 2017). Benefit cost ratio can be again higher as flatbed plantings yielded higher small size tuber which fetches higher price (Kadian et al. 2007).

The study signifies that to keep pace with ever increasing demand of potato. Higher potato yield is of utmost important which require good quality seed size tubers. Flatbed paired row 90 cm bed width (two rows at 40 cm × 20 cm plant to plant spacing) with 80 days haulm killing can be an economically viable option for enhancing seed size tuber percent and B:C ratio for formal and informal potato producing organizations.

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